

CLAIMS

1. A method of detecting gas bubbles in a living body, comprising:
transmitting at least one original electromagnetic signal to a body portion;
5 detecting a signal modulated by a flow of blood in said body portion; and
analyzing a perturbation in said signal to determine at least one of an existence and a
property of a bubble in said blood flow.
2. A method according to claim 1, wherein said original signal comprises a series of
10 pulses.
3. A method according to claim 1, wherein said detected signal comprises a reflected
signal.
- 15 4. A method according to claim 1, wherein said detected signal comprises a signal
modulated by transmission through said flow.
5. A method according to claim 1, wherein said signal comprises a narrow bandwidth
signal.
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6. A method according to claim 1, wherein said signal is visible light.
7. A method according to claim 1, wherein said signal is infra-red light.
- 25 8. A method according to claim 1, wherein said signal is at a wavelength which is
selectively absorbed by hemoglobin.
9. A method according to claim 1, wherein said signal is at a wavelength which is
selectively reflected by blood vessel walls.
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10. A method according to claim 1, wherein said detected signal is detected using multiple
detectors.

11. A method according to claim 1, wherein said original signal comprises multiple original signals from multiple sources.
12. A method according to claim 11, wherein said sources are arranged around a body part
5 in which said bubbles are to be detected.
13. A method according to claim 11, wherein said sources are arranged to view multiple parts of a body.
- 10 14. A method according to claim 11, wherein said signals are detected in series.
15. A method according to claim 11, wherein said signals have different wavelengths.
16. A method according to claim 15, wherein at least two of said different wavelengths
15 have different absorption properties in blood.
17. A method according to claim 11, wherein analyzing comprises combining the effects of said multiple sources.
- 20 18. A method according to claim 1, comprising performing AM on said detected signal.
19. A method according to claim 18, wherein said AM analysis comprises estimating an unperturbated signal and counting zero crossings relative to said estimation.
- 25 20. A method according to claim 19, wherein said estimation is selected to preclude the detection of perturbations below a certain threshold.
21. A method according to claim 19, wherein said estimation comprises an adaptive threshold.
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22. A method according to claim 19, wherein said estimation reduces the effect of systolic-caused changes in said signal.

23. A method according to claim 18, comprising performing FM on said detected signal.
24. A method according to claim 23, comprising combining said AM analysis and said FM analysis.
- 5 25. A method according to claim 1, comprising performing FM on said detected signal.
26. A method according to claim 25, wherein said FM analysis comprises applying a frequency transform to said detected signal.
- 10 27. A method according to claim 25, wherein said FM analysis comprises detecting changes in a delay time of a said detected signal relative to said original signal.
28. A method according to claim 25, wherein said FM analysis comprises detecting a
15 change in amplitude of a frequency component.
29. A method according to claim 1, comprising analyzing said received signal to determine a value or a change in a physiological parameter other than bubbles.
- 20 30. A method according to claim 29, wherein said physiological parameter comprises a heart rate.
31. A method according to claim 29, wherein said physiological parameter comprises an oxygen saturation.
- 25 32. A method according to claim 29, wherein said physiological parameter comprises a respiration rate.
33. A method according to claim 1, wherein said analyzing comprises estimating a number
30 of bubbles.
34. A method according to claim 1, wherein said analyzing comprises estimating a volume of bubbles.

35. A method according to claim 1, wherein said analyzing comprises tracking the formation of at least one bubble.
- 5 36. A method according to claim 1, wherein said analyzing estimating a diameter of at least one bubble.
37. A method according to claim 1, comprising estimating a physiological state for diving purposes based on said analysis.
- 10 38. A method according to claim 1, wherein transmitting comprises transmitting when in contact with a skin surface.
39. A method according to claim 1, wherein transmitting comprises transmitting through a
15 layer of water.
40. A method according to claim 39, wherein said layer is between 1 and 20 mm thick.
41. A method of detecting gas bubbles in a living body, comprising:
20 transmitting at least one original signal to a body portion;
detecting a signal modulated by a flow of blood in said body portion; and
analyzing, using AM analysis, a perturbation in said signal to determine at least one of
an existence and a property of a bubble in said blood flow.
- 25 42. A method according to claim 41, wherein said signal comprises an ultrasonic signal.
43. A method according to claim 42, comprising applying an FM analysis.
44. Apparatus for bubble detection, comprising:
30 at least one electromagnetic signal source adapted to transmit a wave into a body;
at least one sensor adapted to receive said signal after modulation by a flow in said
body; and

circuitry adapted to analyze said received signal and detect the presence of a bubble in said flow.

45. Apparatus according to claim 44, wherein said circuitry is adapted to self-calibrate said
5 apparatus.

46. Apparatus according to claim 44, wherein said circuitry is adapted to detect if a placement of said device is suitable.

10 47. Apparatus according to claim 44, wherein said device is adapted to be worn on a wrist.

48. Apparatus according to claim 44, wherein said device is adapted for underwater use during diving.

15 49. Apparatus according to claim 44, comprising a wireless link.

50. Apparatus according to claim 44, comprising a user input for providing task related information.

20 51. Apparatus for physiological tracking bubble detection, comprising:
at least one electromagnetic signal source adapted to transmit a wave into a body;
at least one sensor adapted to receive said signal after modulation by a flow in said
body; and
circuitry adapted to analyze said received signal and detect at least changes in at least
25 two physiological parameters of said body.

52. Apparatus according to claim 51, wherein said at least two physiological parameters are selected from a group comprising, existence of bubbles, heart rate, respiration rate, blood pressure, oxygen saturation and vascular response.

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53. A method of bubble tracking in a living body, comprising:
transmitting at least one original signal to a body portion;
detecting a signal modulated by a bubble in said body portion; and

analyzing a perturbation in said signal to determine at least one of an existence and a change in size of a bubble in said body portion.